SOUTHERN FOREST RESEARCH

- FORAGE IN UNMANAGED OZARK FORESTS
- SAND PINE ON UNPREPARED SANDHILLS
- LITTER-HUMUS AFTER HARDWOOD REMOVAL
- SAMPLE VARIATION IN FALAYA SILT LOAM
- GIBBERELLIC ACID
  — AND PINE GERMINATION
  — AND LONGLEAF GROWTH

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SOUTHERN FOREST RESEARCH

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As the publication is intended chiefly for specialists and technicians, wide distribution is not intended, though reprints of individual articles will ordinarily be available.

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FORAGE AND GROUND-COVER CONDITIONS IN UNMANAGED OZARK FORESTS

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SOUTHERN FOREST EXPERIMENT STATION

In unmanaged forests of the Arkansas Ozarks, minimal grazing and control of fire from 1947 to 1957 bettered ground-cover conditions but did not improve forage values. Amount of understory vegetation fluctuated considerably from year to year, being influenced chiefly by distribution of rainfall. Yield of herbaceous vegetation in the woodlands after 10 years of conservative use was less than one-fifth of that on open meadow.

The study was conducted in the Springfield Plateau and the Boston Mountains of northwest Arkansas (fig. 1). These provinces lie within an extensive transition zone between the southern and eastern mesophytic deciduous forest and the xerophytic prairie of the Great Plains. Average annual rainfall is approximately 45 inches. Forests, predominantly of upland oaks, hickories, and shortleaf pine, cover approximately 80 percent of the 2.2 million acres in the Boston Mountains and 50 percent of the 1.6 million acres in the Springfield Plateau. Many years of uncontrolled burning, grazing, and logging have reduced production of both forage and commercial timber.

Ozark soils are low in organic matter and nitrogen. Their open, porous nature makes them relatively droughty. Much of the rain percolates through the stony surface to depths beyond plant roots. In the Springfield Plateau, soils are cherty silt loams of limestone origin; in the Boston Mountains they are stony sandy loams derived from sandstone.

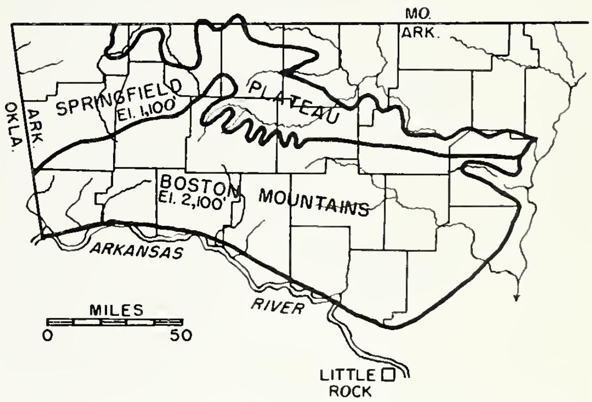

Figure 1.—*The Springfield Plateau and Boston Mountains are major land provinces of the Arkansas Ozarks.*

STUDY AREA AND PROCEDURES

Vegetation and ground-cover conditions were sampled annually during mid-August from 1947 to 1952 and again in 1957 on two woodland locations within the Springfield Plateau and two woodland locations and an open bluestem meadow in the Boston Mountains. Current growth up to a height of five feet was recorded on ten 3.1-foot square plots at each of five locations. Woodland samples were on middle and upper 20 to 25 percent slopes of south and west exposures. The open meadow was on a broad ridge of 5-percent south slope. The 1947-1952 samples were by estimation; in 1957 vegetation was clipped and weighed. Concurrently with the vegetation measure-

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ments, estimates were made of the proportion of plot surface occupied by vegetation, litter, bare rock, and soil. Forage-nutrition aspects of this study have been previously reported.[2]

On the Springfield plots, cattle grazing was light or nonexistent for several years prior to 1947 and throughout the study. Plots at one location burned in 1943 and again in 1947; those at the other location burned in 1935.

On one set of Boston Mountain woodland plots, cattle grazed moderately from 1947 through 1949; there was no grazing in 1950 and 1951, and very light grazing thereafter. One set of plots burned in 1942 and 1947. The other set, which has no grazing history, burned in 1948.

Grazing in the open meadow was heavy in 1947, moderate in 1948 and 1949, absent in 1950 and 1951, and light since then. The meadow burned in 1943.

The woodlands supported a noncommercial stand of low-quality oaks *(Quercus stellata, Q. marilandica,* and *Q. velutina),* hickories *(Carya* spp.), and winged elm *(Ulmus alata).* In 1947, tree stocking per acre varied from 40 to 160 stems 8 inches d.b.h. or larger, plus 1,000 to 1,400 stems less than 8 inches d.b.h. There were scattered shrubs but no trees in the meadow.

The most prevalent desirable forage species was little bluestem *(Andropogon scoparius).* It and other bluestems comprised 75 percent or more of the grasses in the woodlands and 95 percent in the open meadow. Grasses of lesser importance were poverty danthonia *(Danthonia spicata),* panic grass *(Panicum* spp.), and threeawns *(Aristida* spp.). Legumes, mainly lespedeza *(Lespedeza* spp.), and tickclover *(Desmodium* spp.), were the most important forbs. Less prevalent forbs were spurge *(Euphorbia* spp.), sunflower *(Helianthus* spp.), fleabane *(Erigeron* spp.), and aster *(Aster* spp.).

Trees were the most important browse plants, but occasionally shrubs and vines such as blueberry *(Vaccinium* spp.), wildgrape *(Vitis* spp.), blackberry *(Rubus* spp.), and sensitivebrier *(Schrankia* spp.) contributed substantially.

VEGETATION PRODUCTION AND CARRYING CAPACITY

In the woodlands, appreciable quantities of

Figure 2.—*A dense cover of noncommercial hardwoods limited herbaceous growth to scattered openings.*

grass and forbs were found only in the openings (fig. 2).

On the Springfield Plateau herbaceous vegetation (grasses and forbs) weighed 239 pounds per acre in 1947 (table 1). In general, yields were greatest the first and second growing seasons following a burn. With protection from fire and with no grazing or removal of the overstory, yields tended to decline during the study period. Although approximately 77 percent of the herbage was composed of little and big bluestem *(Andropogon gerardi)* and desirable legumes such as tickclover and lespedeza, the carrying capacity for cattle was low. At an assumed proper utilization for all plants and a feed requirement of 20 pounds of air-dry forage per day, maintenance of a mature cow for seven months would have required approximately 31 acres in 1947 and 50 acres in 1957.

Browse, mainly oaks, was the predominant class of vegetation. The trend of production was upward. Oaks are of little browsing value for either livestock or game but have the potential to produce large quantities of mast. The combination of oak mast, the prevalence of other browse plants such as wild grape, and a good distribution of seed-bearing legumes indicated that unmanaged upland hardwood forests may be more valuable for deer, turkey, and quail than for cattle.

In the Boston Mountains, woodland herbage yields were consistently greater than on the Springfield Plateau. With little or no grazing and no timber cutting, yields of grasses and

[2] Read, Ralph A. 1951. Woodland forage in the Arkansas Ozarks. Jour. Range Mangt. 4:391-396, illus.

Table 1.—*Vegetation yields per acre (air-dry weight) on Springfield Plateau and Boston Mountains of northwest Arkansas, 1947 to 1957*

Study area and class of vegetation	1947	1948	1949	1950	1951	1952	1957
				Pounds			
Springfield Plateau woodland							
Grass	72	104	61	56	45	38	21
Forbs	167	241	129	170	180	155	122
Browse	223	311	326	300	338	398	387
Total	462	656	516	526	563	591	530
Boston Mountain woodland							
Grass	136	400	179	193	121	98	239
Forbs	197	357	220	305	206	193	160
Browse	290	406	394	350	473	697	467
Total	623	1,163	793	848	800	988	866
Boston Mountain open meadow							
Grass	465	1,102	813	812	832	995	1,402
Forbs	57	93	135	107	52	14	233
Browse	31	48	91	91	78	125	123
Total	553	1,243	1,039	1,010	962	1,134	1,758

forbs changed very little between 1947 and 1957. Approximately 62 percent of the herbage was in desirable bluestems and legumes. On the average, 26 acres would have furnished a mature cow enough forage for a seven-month season.

Browse also predominated in the Boston Mountains. Yields increased for five or six years following a burn but decreased thereafter because many plants had grown above the 5-foot height class. As in the Springfield Plateau, the habitat appeared more favorable to upland game than to cattle.

Herbage yields on the bluestem meadow were indicative of the potential of nontimbered areas in the Boston Mountains to produce cattle forage. Here, grasses made up about 80 percent of the vegetation and little bluestem 81 percent of the grasses. Grass yields were far in excess of those on wooded areas and with light grazing they tended to increase, being highest in 1957. Forb yields fluctuated considerably between years, and no definite trends were discernible.

Browse plants were few in 1947. With protection from fire they increased in numbers, particularly along the edge between meadow and forest (fig. 3). Even so, browse comprised less than 10 percent of the total vegetation in 1957. Oaks and eastern redcedar *(Juniperus virginiana)* were the chief invaders.

Vegetative growth in the meadow varied considerably between years. During the poorest year 15 acres were required to sustain a cow for a seven-month season; in the best year, 1957, only 6 acres were needed.

Figure 3.—*Oaks and eastern redcedar are gradually invading this meadow in the Boston Mountains. The area was last burned in 1943. When photo was taken in 1957, grass production was 1,402 pounds per acre.*

MOISTURE-VEGETATION RELATIONSHIPS

Fluctuations in vegetation coincided with distribution of growing-season rain. Below-normal periods of 20 to 40 days occurred almost every year. Yields in August were largely a reflection of rain during the prior 30 days.

In 1947, spring rain was adequate but a deficit in July and August resulted in very low yields. There was a short dry spell in April 1948 but ample rains for the rest of the growing season made this one of the best years. Early-season deficits were more prolonged in 1949 and 1951, but the retardation in early growth was largely overcome by normal to excessive rain in June and July. Insofar as rain and vegetation were concerned, 1950 was about average. In May and June 1952, growth practically ceased during a 40-day drought but revived under normal to excessive rain in July and August. Total yields were above average. With the exception of the Springfield Plateau, where grass was scarce, ample rains in 1957 caused above-normal grass growth. Forb yields this year were erratic. Browse was not greatly affected because most of the foliage was above the 5-foot measuring zone.

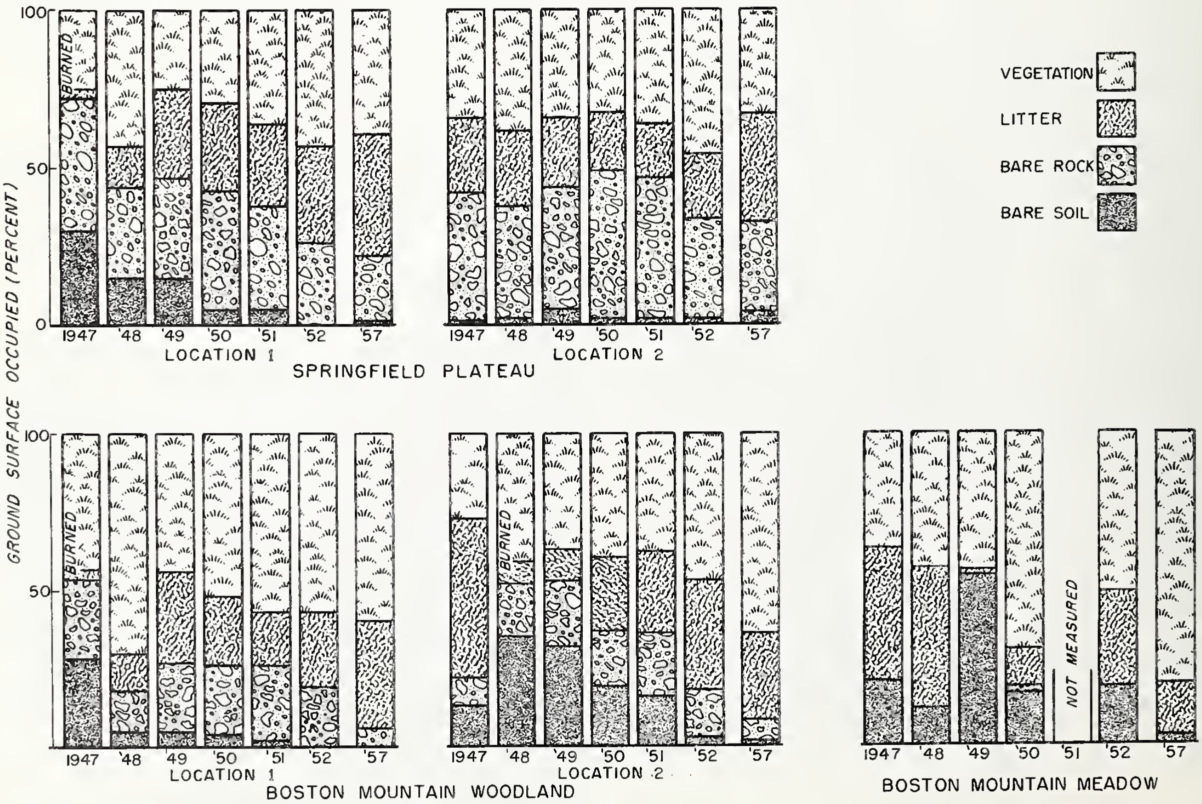
These fluctuations in vegetation and rain, between and within years, complicate livestock management. An abundance of forage may change to a scarcity, or vice versa, in a short time. It is extremely difficult to regulate cattle numbers accordingly. Too, the frequency and duration of these periods are impossible to predict. As a precaution, ranges should be stocked at a light to moderate rate, so as to insure an adequate forage supply under average conditions and to buffer against short droughts. During prolonged drought cattle weights and productivity may drop sharply. In some cases cattle may have to be sold for adverse prices. Additional sources of feed, such as other range, stored hay, or concentrates, are the only guards against such emergencies.

For wildlife, the critical feed period generally comes during late fall and winter. Vegetation inventories in the fall give some indication as to the availability of forage in relation to wildlife populations. In years when mast or forage is sparse, a severe imbalance may be averted by reducing game numbers through more intensive hunting.

SURFACE CONDITION OF SOIL

Vegetation occupied approximately one-third of the ground surface on the Springfield Plateau (fig. 4). Although the proportion va-

Figure 4.—*Ground cover conditions in unmanaged Arkansas Ozark forests.*



ried considerably between years, generally coinciding with vegetative growth and precipitation, there was no definite trend during the course of the study. Vegetative coverage was greater in the Boston Mountain woodlands and meadow. Again there was large variation between years, but the trend was upward. Coverage was greatest in 1957 and on plots where grass yields were highest.

In both the Springfield Plateau and Boston Mountain woodlands litter occupied 7 percent or less of the soil surface near the end of the first growing season following a burn (fig. 4). It increased rapidly for the next two years and then gained more gradually. On the average, the greatest coverage was reached in 1957. On the open grassland, litter tended to decrease, mainly because of an increase in coverage by grass.

Exposed surface—bare rock and soil—was greatest immediately following a burn. The area of exposed rock in the woodlands declined gradually, with the minimum area dependent upon the size and abundance of rocks. Even though Location 2 of the Springfield Plateau had gone unburned since 1935, rock still comprised 29 percent of the surface in 1957. On Location 1 of the Boston Mountains, as little as 7 percent of the surface was in rock after 10 years of no burning. No rocks were recorded on the Boston Mountain meadow. The area of exposed bare rock is useful in soil description but is not a reliable indicator of erosion hazard in cherty soils.

The three burns of 1947 and 1948 occurred during the winter and thus left the soil bare for several months. By August an average of 31 percent of the surface was still classified as bare soil. The proportion continued generally high for another year or two but varied with the amount of vegetative growth at the different locations. At the end of five or six years, very little soil was exposed in the woodlands (fig. 5). Thus, susceptibility to erosion was

Figure 5.—*Ungrazed and unburned since 1948, this woodland plot has an almost complete cover of vegetation and litter.*

extremely high the first year following burning, somewhat less so the next two or three years, and negligible thereafter, so long as the burns were not repeated and grazing was light.

The Boston Mountain meadow, even though unburned since 1943, varied considerably in proportion of bare soil. The proportion was quite large in years of low rainfall and poor vegetative growth, especially when livestock grazed the tract. Only with complete protection from grazing and in a year of ample rainfall did the grassland attain a minimum of bare soil comparable to that of the woodlands. Conservative grazing is necessary to prevent the Ozarks grasslands from becoming severe erosion hazards.

SOUTHERN FOREST RESEARCH
1:1-6. November 1960.
Southern Forest Experiment Station
Forest Service
U. S. Department of Agriculture

PLANTED SAND PINE GROWS WELL ON UNPREPARED FLORIDA SANDHILLS

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On the deep sands of western Florida, sand pine planted on unprepared sites grew well with little or no release from competing vegetation. Other southern pines did poorly without release.

The study, made on the Chipola Experimental Forest near Marianna, tested sand pine *(Pinus clausa* [Chapm.] Vasey), longleaf *(P. palustris* Mill.), slash *(P. elliottii* Engelm.), loblolly *(P. taeda* L.*)*, and shortleaf *(P. enchinata* Mill.). The pines were planted as 1-0 seedlings and scheduled for a single release either immediately upon planting or 1, 3, or 5 years thereafter.

Release consisted of spraying 2,4,5-T on the basal portions of all trees 4.5 feet tall or taller. The chemical was mixed with oil at the ratio of 1 to 20, by volume, and applied in the dormant season. It killed the overstory crowns and prevented rootstock sprouting, but wiregrass *(Aristida stricta* Michx.) and small oaks (principally *Quercus laevis* Walt. and *Q. incana* Bartr.) responded so vigorously that competition became nearly as severe as on unreleased check plots.

Treatments were tested in split plots arranged in a randomized complete block design. Species were assigned to major plots and release treatments to minor plots.

One complete set of plots was installed in the winter of 1951-52 (1952 planting) and another the following winter (1953 planting).

RESULTS

All plots were tallied annually through the fall of 1955. By then all longleaf pines planted in 1952 and most of those planted in 1953 were dead. Survival and growth of loblolly and shortleaf pine were extremely poor. Slash and sand pines survived fairly well, but because slash pine height growth was inadequate the scheduled fifth-year release was made only on sand pine.

By the summer of 1959, survival averaged 55 percent for sand pine and 51 percent for slash pine planted in 1952, and 30 and 44 percent, respectively, for trees planted in 1953. Neither species differences nor differences due to time of release were statistically significant.

Differences between the two species in total height were striking, however. Sand pines planted in 1952 averaged 14.3 feet tall, and those planted in 1953 grew 12.6 feet. Slash pine height averaged 4.9 feet and 3.8 feet for the 1952 and 1953 plantings, respectively (table 1). The differences between species were highly significant.

Poisoning the oak overstory at time of planting produced taller pines than later or no release; the longer release was delayed, the

Table 1.—*Total heights of sand and slash pine in summer, 1959*

Time of release	Planted 1952		Planted 1953	
	Sand	Slash	Sand	Slash
	Feet			
At planting	17.2	6.4	14.4	4.8
After planting				
1 year	14.2	5.8	13.0	4.1
3 years	14.1	4.9	13.9	3.8
5 years	13.1	[1] 3.9	11.5	[1] 2.8
No release	13.3	3.8	11.2	3.3
Mean	14.3	4.9	12.6	3.8

[1] Scheduled release not made. Data are included in the means but not in the analyses.

poorer was pine growth. Of greater importance, though, is that sand pine grew more than one and one-half feet per year on untreated areas. It is now pushing through the scrub oak overstory and promises to overtop it in the near future. Slash pine, under similar conditions, grew about one-half foot per year and probably will never overtop the oaks.

The ability of sand pine to compete successfully with oaks and wiregrass has special significance for sandhills landowners, many of whom are unable or unwilling to incur the costs of the intensive site preparation[1] needed for other species. Planting or direct seeding sand pine on partially or even unprepared sites may offer a solution to their problem.

Figure 1.—*Eight years after being planted in the wiregrass-scrub oak rough, most of these sand pines have overtopped their competition.*

SOUTHERN FOREST RESEARCH
1:7-8. November 1960.
Southern Forest Experiment Station
Forest Service
U. S. Department of Agriculture

[1] Woods, F. W. 1959. Converting scrub oak sandhills to pine forests in Florida. Jour. Forestry 57:117-119.

HARDWOOD REMOVAL LESSENS LITTER-HUMUS IN OZARKS

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SOUTHERN FOREST EXPERIMENT STATION

Weight of the litter-humus layer on the forest floor declined by half within a year after hardwoods in the Arkansas Ozarks were killed with 2,4,5-T sprays. Corresponding reductions were noted in retention storage of moisture, and greater ones in detention storage.

The experimental area is near Fayetteville, on Bodine-like soils. The surface 3 inches are grayish-black silt loam with much incorporated organic matter. Beneath this layer is 8 to 15 inches of gray silt loam that grades into a red-brown clay to clay loam. In all horizons chert comprises up to 75 percent of the total soil volume. Associated soils in this limestone-derived hill and valley section are Baxter, Clarksville, Talbott, and Nixa. Elevations are from 500 to 1,500 feet. Relief is moderately sloping to steep.

The study area is very similar to much of the cutover woodland in the mountains of north Arkansas. In 1957, after the merchantable oaks had been harvested, it supported a moderately well-stocked stand of mixed oaks 4 to 10 inches in d.b.h. The basal area was approximately 60 square feet per acre. Eighty acres were aerially sprayed in June 1957 with a low-volatile ester of 2,4,5-T in oil and water. This spraying killed the overstory. The woody understory was killed by a second spraying in the summer of 1958. The remainder of the 155-acre tract was left untreated. On the sprayed portion native grasses took over—primarily bluestems *(Andropogon gerardi, A. scoparius,* and *A. virginicus)* and indiangrass *(Sorghastrum nutans).*

Litter-humus was sampled in February 1958 and again in February 1959. The sample included:

Litter. Undecomposed plant remains, excluding twigs over 0.25 inch in diameter.

Fermentation layer. Partially decomposed litter.

Humus. Decomposed litter, whose origin could no longer be determined by visual examination but which could easily be separated from the soil. Humus intimately mixed with mineral soil was not sampled.

A square frame that enclosed 0.1 milacre was placed over the litter at sampling points. The litter-humus was cut along the edge of the frame with a knife and lifted onto a wire screen, where loose soil was shaken out. The samples were placed in polyethylene bags and transported to the laboratory, where they were soaked in water for 3 hours, allowed to drain for 30 minutes, and weighed. Water lost during this period was called detention storage. The samples were then air-dried at 75 degrees F. and 45 percent humidity until weight equilibrum occurred. Water lost during this period was called retention storage. Periodic weighing permitted establishment of drying curves. Samples were subsequently oven-dried.

RESULTS

In February 1958, both areas had litter-humus weights in the range 7,147 to 7,648 pounds per acre, oven-dry, with standard deviations of $\pm$ 1,002 and $\pm$ 1,279. As a result of ample soil moisture and excellent tree growth in 1958, litter-humus on the forested area increased to 9,569 pounds per acre with a standard deviation of $\pm$ 1,448. During the same period weights on the cleared area dropped to 4,238 pounds per acre $\pm$ 965—a reduction of 45 percent. This loss of nearly one-half of the organic layer occurred from increased oxidation and from the lack of new litter in 1958.

Water storage.—In 1958, the total storage in litter-humus on both areas was 0.23 area inches. It remained at this point for the forested samples in 1959, but dropped to 0.16 inch on the cleared portion. In February 1959, the litter on forested plots held 459 cubic feet per acre of detention water, as compared to 188 cubic feet per acre—40 percent as much—on sprayed plots. Detention storage was 0.126 area inch on the forested site, and 0.052 on the cleared. Samples from the forested area held 300 percent of their oven-dry weight in detention storage; cleared-area samples held 285 percent.

Retention storage (table 1) on the cleared area was reduced in proportion to litter-humus weight. Samples from the forested area held 247 percent of their oven-dry weight in retention storage; those from the sprayed area, 273 percent.

Table 1.—*Retention storage of water in litter-humus*

Site	1958 Per acre	1958 Area depth	1959 Per acre	1959 Area depth
	Cu. ft.	*Inches*	*Cu. ft.*	*Inches*
Forested	361	0.100	389	0.107
Sprayed	342	.095	173	.050

Drying curves.—The 1958 samples from both forested and sprayed areas required 12 days to air-dry. The air-dry samples retained an average of 20 percent moisture (oven-dry basis). In 1959, the samples from the forested area, being heavier, took 13.5 days to reach air-dryness, but samples from sprayed plots dried in 9 days.

Even more significant differences between treatments are revealed by the times required for the samples to lose 90 percent of their retention moisture. Up to this point, the samples dried rapidly; after it, the drying curves flattened. The 1958 samples from both areas lost 90 percent of their retention moisture in 7 days. The 1959 samples from the forested area required 9 days, those from the sprayed area took 3 days.

Widespread tree removal thus probably would have considerable effect upon the hydrology of such an area.

SOUTHERN FOREST RESEARCH
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Forest Service
U. S. Department of Agriculture

SAMPLE VARIATION IN A FALAYA SILT LOAM

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How many observations are needed to estimate physical properties of a soil? To help answer this question, a 50- by 60-foot forested plot on Falaya silt loam soil in Warren County, Mississippi, was divided into 120 5- by 5-foot squares.[1] Samples were taken from the 6- to 12-inch layer below the surface in each square.

The soil was deep and imperfectly drained, and had never been cultivated. The Falaya series, composed of sediments washed from loessial uplands and terraces, is considered one

Table 1.—*Means and standard deviations for various properties of Falaya silt loam*

Soil property	Depth sampled	Plot mean (120 observations)	Standard deviation (s)	Precision expected when estimating mean from various numbers (n) of observations [1]			
				n=30	n=10	n=5	n=2
	Inches						
Texture							
(percent of oven-dry weight)							
Sand	6-9	4.90	1.0	0.4	0.7	1.2	9.0
Silt	9-12	83.87	1.8	.7	1.3	2.2	16.2
Clay	6-9	11.18	1.6	.6	1.1	2.0	14.4
Organic matter							
(percent of oven-dry weight)	6-9	1.29	.5	.2	.4	.6	4.5
Bulk density							
(g/cc)	9-12	1.33	.06	.02	.04	.08	.54
Moisture							
(percent of oven-dry weight)							
Dry	6-12	29.44	2.2	.8	1.6	2.7	19.8
Wet	6-12	36.08	3.3	1.2	2.4	4.1	29.7
60-cm tension	6-9	35.42	2.4	.9	1.7	3.0	21.6

[1] Errors (at 95-percent level) for various sampling intensities were computed from the relationship $E = ts\sqrt{n}$, where t = Student's t for (n −1) degrees of freedom.

[1] Krumbach, A. W. 1959. Effects of microrelief on distribution of soil moisture and bulk density. Jour. Geophys. Res. 64: 1587-1590.

of the most variable of loessial-derived soils. Hence the number of observations necessary to estimate its properties probably would be near the upper limit for any upland or terrace loessial soil.

The number of observations needed, of course, depends on the precision desired. Table 1 shows the precision (95-percent probability level) expected for various sampling intensities. The 3-inch soil layers indicated in the table represent the most variable of the two increments sampled—i.e., the 6- to 9-inch and 9- to 12-inch layers. Moisture was sampled only in 6-inch increments.

For sand content, for example, a sample of 5 observations would estimate the plot mean to within ± 1.2 percent. To increase this precision to ± 0.4 percent would require 30 observations.

Table 1 does not reveal the variation characteristic of all Falaya silt loam, but only that of the particular forested plot studied. It may, however, provide a guide to intensity of sampling on loessial soils.

SOUTHERN FOREST RESEARCH
1:11-12. November 1960.
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RESPONSE OF SELECTED CONIFEROUS SEEDS TO GIBBERELLIC ACID

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At concentrations of about 150 milligrams per liter, gibberellic acid significantly improved germination and height growth of loblolly pine. Germination of longleaf pine was not significantly affected, but the response to 150, 225, and 300 mg./liter was progressively greater. Effects on seeds of eastern redcedar were indeterminate.

Most attempts to use gibberellic acid on conifers have had negative results *(3, 5, 7, 8)*, though applications to loblolly seedlings have sometimes increased stem and root growth *(1, 4)*.

METHODS

Unstratified seeds from single lots of loblolly pine *(Pinus taeda* L.), longleaf pine *(Pinus palustris* Mill.), and eastern redcedar *(Juniperus virginiana* L.) were treated with a 10-percent potassium salt of gibberellic acid at concentrations of 0, 75, 150, 225, and 300 mg./l. Torrey's modification of a Bonner medium *(6)*, with the aforementioned concentrations of gibberellic acid substituted for indoleacetic acid, was added as a supplement to half the seeds. The resulting 5 gibberellic acid and 5 supplemented treatments were applied in: (a) distilled water, (b) 5-percent methyl cellulose, and (c) dry talc. The germination medium was a washed sand and vermiculite substrate and a vermiculite overlay.

The design was a randomized block with 3 replications each containing 30 factorial treatment combinations split by 3 species. Each species was represented by 450 seeds, *viz.*, 5 seeds in each of 3 blocks for each of the 30 treatments. The germination and growth data were analyzed by conventional analysis of variance and arrayed treatment means were compared by Duncan's test *(2)*.

Thrice-weekly measurements of germination were made for 90 days following emergence of the first seedling. To measure the effect of treatment on height growth, seedlings were transplanted in plugs of undisturbed germinating medium. The transplant bed was a sand-vermiculite mixture.

RESULTS

The response to gibberellic acid was erratic both among and within species. None of the redcedar seeds germinated, although 62 percent of the seeds recovered at the conclusion of the test were full and apparently viable. The acid may have suppressed germination, but failure of the treatment to pervade a resinous testa seems more likely.

Differences in the total germination of longleaf pine were non-significant, but the response to concentrations of 150, 225, and 300 mg./l. was progressively greater (fig. 1). This trend suggests that higher concentrations or longer treatment might have produced a more marked response. Germination was complete within 3 weeks after the first seedling emerged; only

4 percent of the seeds recovered appeared viable. The supplement did not affect either germination or height growth, although there were significant differences in germination attributable to the carrier, with distilled water being the best.

The germination of loblolly pine seeds remained fairly constant throughout the 90-day period. Almost 35 percent of the ungerminated seeds appeared viable. No significant differences in germination were attributable to any single factor except concentration, with 150 mg./l. being superior to the other concentrations and the control. A significant interaction between carrier and concentration also was noted. While no single factor had a significant effect on height growth of loblolly pine, the interaction of concentration with carrier was significant, and the interaction of concentra-

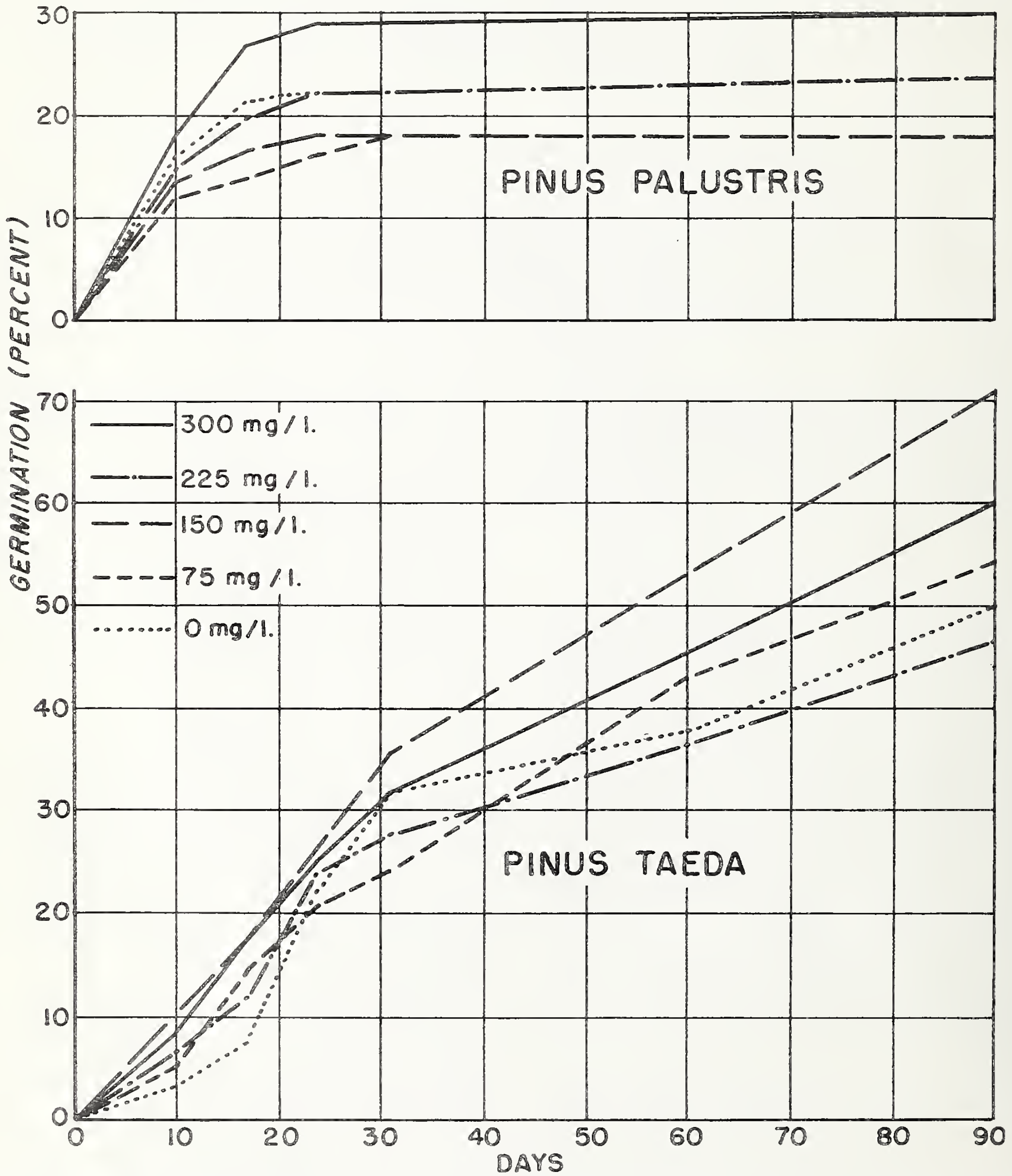

Figure 1.—*Response of longleaf and loblolly pine seeds to various concentrations of a 10 percent potassium salt of gibberellic acid.*

tion and supplement was highly significant. The 150 mg./l. treatment without the supplement produced the tallest seedlings. This experiment suggested that longer treatment and concentrations lower than 150 mg./l. might further increase the rate and total germination of loblolly pine seeds.

Accordingly, a second and similarly designed experiment employing three randomized blocks and 20 factorial treatment combinations was installed. Loblolly pine seeds were stratified at 34° F. for 1, 2, 3, and 4 days in peat soaked with aqueous solutions containing 0, 50, 100, 150, and 200 mg./l. of the 10 percent potassium salt of gibberellic acid. Fifteen hundred seeds were sown and the resultant seedlings grown in a sand-vermiculite substrate (25 seeds for each of the 20 treatment combinations in each of 3 blocks).

Stratification in treated peat did not significantly affect the germination values[1] as determined after 30 days. The growth of the resultant seedlings, however, showed a marked and positive response to both concentration and treatment interval at the end of a 120-day growth period (fig. 2). Each increase in concentration and treatment interval through 150 mg./l. for 3 days resulted in progressively taller seedlings; thereafter the average seedling height decreased.

Figure 2.—*Growth response of loblolly pine seedlings stratified for 2 and 4 days in media treated with 5 concentrations of a 10 percent potassium salt of gibberellic acid.*

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GIBBERELLIC ACID FAILS TO STIMULATE GROWTH OF LONGLEAF PINE SEEDLINGS

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Height growth of yearling longleaf pines was not promoted by foliage sprays of gibberellic acid in oil or water.

The following information may be of value to those concerned with the gross responses of plants to growth regulators. Westing's recent article [2] points up the value of such reports, negative though the results may be.

Longleaf pine seedlings (1-0 stock) were planted in an irrigated nursery in January 1957 on the Chipola Experimental Forest in west Florida. Each of the following treatments was applied to 5 replications of 40 trees each:

1. No treatment—check.
2. 0.5 percent gibberellic acid (GA) in a lanolin emulsion was applied in a very small warm drop on the tip of the terminal bud and allowed to run down over the bud, March 11, 1957.
3. 1.0 percent GA in a lanolin emulsion applied as in treatment 2.
4. 100 p.p.m. aqueous solution of GA sprayed on leaves and bud, March 11, 1957.
5. 400 p.p.m. aqueous solution applied as in treatment 4.
6. 100 p.p.m. of GA in non-phytotoxic oil sprayed on leaves and bud, March 11, 1957.
7. 400 p.p.m. of GA applied as in treatment 6.
8. 100 p.p.m. aqueous solution of GA sprayed repeatedly on leaves and bud: on March 11, April 13, and May 13, 1957.
9. 400 p.p.m. of GA applied as in treatment 8.
10. 1,000 p.p.m. aqueous solution of GA applied as in treatment 4.

The study plots were weeded twice by hand during the growing season, and watered as necessary to maintain favorable growing conditions.

Results were negative; the gibberellic acid did not accelerate longleaf pine bud development or growth. By May of 1958, only one of the 2,000 seedlings had started height growth.

The acid also failed to induce growth when applied to longleaf seeds or newly emerged seedlings in a greenhouse. However, water solutions caused the foliage to be much greener than normal.

[1] This study was carried out while the author was on the staff of the Marianna (Florida) Research Center of the Southern Forest Experiment Station. He is now Assistant Professor of Silviculture, School of Forestry, Duke University, Durham, North Carolina.

[2] Westing, A. H. 1959. Effect of gibberellin on conifers: generally negative. Jour. Forestry 57:120-122.

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